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OPERATING EXPERIENCE WEEKLY SUMMARY

Office of Nuclear and Facility Safety

February 26 - March 4, 1999

Summary 99-09

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EVENTS

1. FATAL EXPLOSION AT A COMMERCIAL CHEMICAL PLANT

On February 19, 1999, an explosion at a Concept Sciences, Inc., chemical plant near Allentown, Pennsylvania, took the lives of five workers and injured at least 13 persons, including five firefighters. The blast completely destroyed a 45,000-square-foot section of the plant, damaged nearby buildings, and rained debris over a wide area (Figures 1-1 and 1-2). The blast also formed a crater approximately 18 feet in diameter and 4 feet deep through the building's concrete floor. The shock wave from the blast was felt for up to 5 miles and the sound carried for more than 15 miles. Workers were handling a solution of hydroxylamine and potassium salts when the accident occurred. DOE uses process quantities of hydroxylamine nitrate at the Savannah River F-Canyon, and other sites may store legacy hydroxylamine compounds or may use them in laboratory quantities. (Photos and description of event courtesy *The Morning Call* newspaper, Allentown, Pennsylvania)

Figure 1-1. Destruction at Concept Sciences, Inc., Facility

Figure 1-2. Destruction at Concept Sciences, Inc., Facility

Hydroxylamine, NH_2OH, is a commercially available compound with chemical properties similar to ammonia. It is soluble in water and is usually supplied as an aqueous solution. The solid form, produced only under carefully controlled laboratory conditions, decomposes violently at normal ambient temperatures. Pure aqueous solutions are considered stable up to approximately 70 weight-percent of hydroxylamine.

Concept Sciences, Inc., had developed an innovative process for producing 30 and 50 weight-percent, ultrapure aqueous solutions of hydroxylamine. The process includes discrete steps for mixing, distillation, and filtration. The company had conducted the process several times on a laboratory scale to produce sample quantities for evaluation by potential buyers and had experienced no difficulty. The explosion reportedly occurred as the workers were distilling several thousand pounds of 50 percent solution mixed earlier, during the first production run at the facility. Distillation consists of "gently" heating the solution to approximately 130 degrees F to drive off hydroxylamine vapors and concentrate most of the potassium salt by-products of the mixing process.

The accident is being investigated by the U. S. Chemical and Hazard Investigation Board, an independent government agency. Officials have not yet determined the cause or causes of the explosion, or even that hydroxylamine was a factor. However, hydroxylamine is the only potentially unstable compound known to be in the facility. NFS will continue to track this occurrence and may provide additional information as it becomes available.

This event serves as a reminder of the instability of the hydroxylamine family of compounds and the need to maintain ongoing positive control of their use and storage. DOE published DOE/EH-0555, *Technical Report on Hydroxylamine Nitrate*, following the Plutonium Reclamation Facility accident in May 1997. This comprehensive report describes that accident and others, describes the uses, characteristics, and hazards of hydroxylamine compounds, and presents recommendations for their safe handling and storage. Facility managers should review their inventories of hydroxylamine compounds and should ensure that handling conditions and practices are consistent with the technical report. Additional information on these compounds can be found in the following documents.

- Occurrence Report No. RL--PHMC-PFP-1997-0023 (Final).
- DOE/EH-0554/Safety Alert 97-1, *Chemical Explosion at Hanford.*
- DOE/RL-97-59, *Accident Investigation Board Report on the May 14, 1997, Chemical Explosion at the Plutonium Reclamation Facility, Hanford Site, Richland, Washington.*
- Lessons Learned 1997-RL-HNF-0018R, *Tank Explosion at Plutonium Reclamation Facility.*

KEYWORDS: chemical, explosion, fatality

FUNCTIONAL AREAS: Chemistry

2. RISKS OF USING ALUMINUM REGULATORS IN HIGH-PRESSURE OXYGEN SYSTEMS

On February 17, 1999, the National Institute for Occupational Safety and Health (NIOSH) and the Food and Drug Administration (FDA) issued a public health advisory to fire departments and other emergency care and health care employers and workers about an occupational risk from aluminum attachments or regulators that control the flow of oxygen from pressurized oxygen tanks or cylinders, often used by fire departments and emergency medical services and in health care settings. Over the past 5 years, FDA has received 16 reports of aluminum regulators used with oxygen cylinders burning or exploding. These incidents caused severe burns to 11 health care workers and patients. Many of the incidents occurred during emergency medical use or during routine equipment checkout. FDA and NIOSH believe that the aluminum in these regulators was a major factor in both the ignition and the severity of the fires.

Allied Healthcare Products, Inc., is recalling all oxygen regulators sold under the Life Support Products (LSP) brand to replace aluminum components in their high-pressure chambers with brass components. LSP oxygen regulator users will be able to have the regulator parts on their LSP 106, LSP 270, LSP 280, LSP 370, and LSP 735 series regulators replaced at authorized service centers. The Allied Healthcare Products recall coordinator may be contacted at (800) 231-5273 or by e-mail at RRC@alliedhpi.com. The recall announcement is available at http://www.alliedhpi.com/announcements.html. The FDA and NIOSH advisories and recommendations are available at http://www.fda.gov/cdrh.oxyreg.html and http://www.cdc.gov/niosh.oxyrgl.html.

KEYWORDS: oxygen, regulator

FUNCTIONAL AREAS: Fire Protection, Industrial Safety

3. IMPROPER MATERIAL STORAGE RESULTS IN CRITICALITY VIOLATION

On February 18, 1999, at the Rocky Flats Environmental Technology Site, a facility safety officer declared a criticality infraction when facility personnel discovered twelve 10-gal salt residue drums stored against a wall in room A and a row of JH-98 drums was stored on the opposite side of the wall in room B. Investigators determined that the criticality safety evaluation does not permit fissile material storage within 24 inches of JH-98 drums even if separated by a wall. Investigators determined that facility personnel had moved the salt residue drums into room A and positioned them along the wall that adjoined room B without considering the contents of room B. The criticality safety personnel posted all drums as “no movement” until a recovery plan could be developed. Failure to meet spacing and handling requirements resulted in reduced criticality safety margins. (ORPS Report RFO--KHLL-371OPS-1999-0007)

The facility manager held a fact-finding meeting and determined that each drum held material containing more than 200 g plutonium. Meeting attendees learned that different organizations were responsible for performing nuclear safety audits in the rooms and that there was no communication between the two organizations regarding the contents of the rooms or the storage requirements. They also learned that the room A side of the wall contained a posted operator aid that stated no storage was permitted, but that operators did not notice it because it was above eye level. Meeting attendees learned that facility personnel performing nuclear safety audits evaluate room contents to ensure storage requirements are met but are not required to review operator aid postings or the contents of adjacent rooms.

NFS has reported criticality safety infractions at Rocky Flats in several Weekly Summaries. Some examples follow.

- Weekly Summary 97-46 reported that a DOE facility representative observing residue-sampling operations noticed that two containers were not stored in designated fixed positions in a storage cabinet, violating criticality spacing requirements. Investigators determined that the residue-sampling team had also violated procedures when they opened a drum containing fissionable material without obtaining a criticality safety evaluation or determining criticality safety limits. (ORPS Report RFO--KHLL-371OPS-1997-0096)
- Weekly Summary 96-37 reported that workers had moved drums into a storage area with previously infracted drums, resulting in a criticality safety violation. Corrective actions included improving communications between operations staff and criticality safety engineers. (ORPS Report RFO--KHLL-771OPS-1996-0148)

OEAF engineers searched the ORPS database for events involving drum storage criticality violations from January 1990 to present and found 175 occurrences. Of the 175 occurrences, 75 were at Rocky Flats. Figure 3-1 shows the distribution of root causes for drum storage criticality violations DOE-wide. A review of these occurrences shows that managers reported 52 percent of the root causes as management problems and 27 percent as personnel errors. Further review of the management problems shows that at Rocky Flats, 50 percent were reported as inadequate administrative control and 25 percent were reported as policy not adequately defined, disseminated, or enforced. However, review of the management problems at the remaining DOE facilities shows that 29 percent were reported in each of three subcategories: (1) inadequate administrative control, (2) policy not adequately defined, disseminated, or enforced, and (3) other management problems. Figure 3-2 shows the number of drum storage criticality violations reported at Rocky Flats compared to the remaining field offices. Further review of the drum storage criticality violations shows a decreasing trend in the number of occurrences at Rocky Flats since 1996 and an increasing trend at the remaining field offices since 1995.

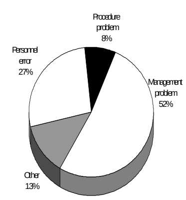

Figure 3-1. Root Causes for Drum Storage Criticality Violations[1]

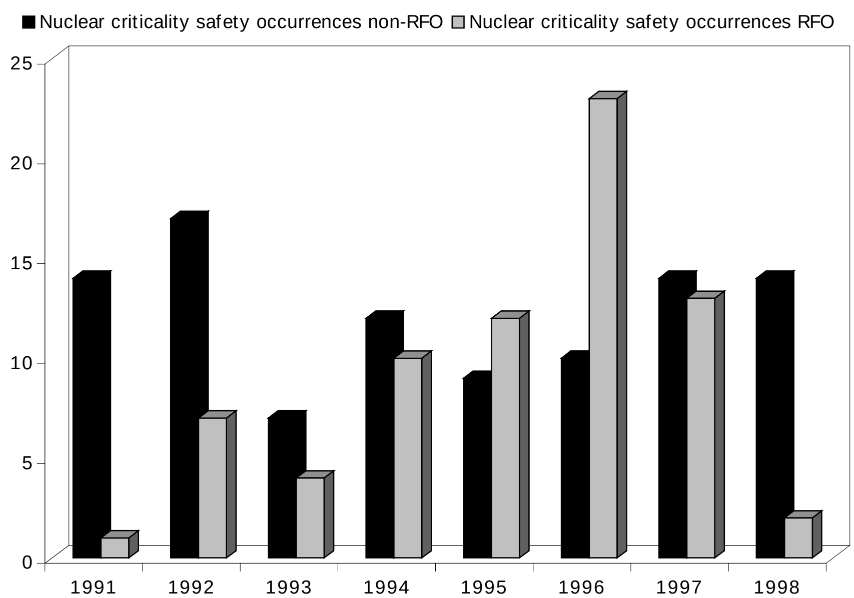

Figure 3-2. Rocky Flats Drum Storage Criticality Violations

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[1] OEAF engineers searched the ORPS database using the graphical user interface for reports with a nature of occurrence code of "1A" (nuclear criticality safety) AND all narrative containing (drum OR container OR can) AND (spacing OR stored) from January 1990 to present and found 175 occurrences.

Compared to Other Field Offices[1]

These events illustrate the importance of a good conduct of operations program. In the latest event, (1) personnel failed to adhere to posted operator aids, (2) procedures for evaluating storage locations were inadequate, and (3) rooms within the facility were controlled by different organizations that did not adequately communicate with each other. The responsibility for ensuring adequate planning and control of work activities resides with line managers. Facility managers and supervisors should ensure that plan-of-the-day meetings or pre-job briefings are performed and that they cover material spacing requirements, personnel responsibilities, and the expectations that tasks are understood and procedures followed. They should also monitor activities by performing frequent direct observations of specific activities and routine walk-downs. In addition, when more than one organization is responsible for work performance in a facility, strong communication paths should exist to prevent workers from performing conflicting tasks.

Facility managers should ensure that all operators and supervisors are familiar with operating procedures and understand their purpose and use. This is especially important when criticality safety issues are involved.

- DOE O 420.1, *Facility Safety,* provides direction on establishing criticality safety program requirements. Section 4.3, "Nuclear Criticality Safety," invokes the requirements of several ANSI/ANS standards, including those contained in ANSI/ANS-8.19-1984.

- DOE O 5480.19, *Guidelines for the Conduct of Operations Requirements for DOE Facilities*, provides guidance on sound operating practices and invokes several ANS standards for basic elements and control parameters in programs for nuclear criticality safety. It states that accurate communications are essential for safe and efficient facility operation. Chapter VIII, "Control of Equipment and System Status," states that the operating shift should know the status of equipment and systems, and it discusses necessary communications needed to maintain proper configuration control.

- DOE-STD-1071-94, *Guideline to Good Practices for Material Receipt, Inspection, Handling, Storage, Retrieval, and Issuance at DOE Nuclear Facilities,* section 3.4.2, discusses the precautions to be considered for moving materials and recommends that personnel who perform this work should be trained using a performance-based program. DOE standards are available at http://www.doe.gov/html/techstds/standard/standard.html.

- ANSI/ANS-8.19-1984, *Administrative Practices for Nuclear Criticality Safety,* provides the criteria for administration of an effective nuclear criticality safety program for operations outside reactors in which there exists a potential for criticality accidents. Sections 4, 5, and 6 address responsibilities for managers, supervisors, and members of the nuclear criticality safety staff.

KEYWORDS: nuclear criticality safety, work control

FUNCTIONAL AREAS: Nuclear/Criticality Safety, Operations, Material Handling/Storage

4. REACTOR EXPERIMENT CAPSULE HOLDER ASSEMBLY INCORRECTLY POSITIONED SINCE 1994

On February 17, 1999, at the Idaho National Engineering Environmental Laboratory Advanced Test Reactor, reactor operations personnel discovered that the east flux trap experiment capsule holder assembly had been rotated 90 degrees from its intended position. Reactor operations personnel were changing the experiment targets when they noticed that the irradiation holes in the capsule holder assembly were not oriented as indicated on the core diagram in the detailed operating procedure they were using. An experiment engineering representative confirmed that the radial orientation of the capsule holder assembly was incorrect and that it had been mispositioned since 1994. The reactor programs manager directed operators to stop all core change operations until an evaluation is completed. Although misorientation of the capsule holder assembly did not result in operation of the advanced test reactor outside its authorization basis, future operating cycles would have been affected had the misorientation not been identified. (ORPS Report ID--LITC-ATR-1999-0006)

Investigators determined that the east flux trap experiment capsule holder assembly was installed during a core internals changeout outage in 1994 and that no changes have been made to its orientation since then. They also determined that low specific activity (LSA) cobalt rods have been installed in the capsule holder irradiation holes since 1995. Reactor operations personnel were replacing the LSA cobalt rods with high specific activity (HSA) cobalt, strontium, and iridium targets and aluminum fillers when they noticed the discrepancy. Investigators determined that because the core physics model used did not assume a specific LSA cobalt rod orientation for the operating cycles in which these rods were installed, the advanced test reactor was not operated outside its safety authorization basis. However, the core physics model for the next operating cycle did require the east flux trap capsule holder assembly to be properly oriented to ensure a specific orientation for the new HSA cobalt, iridium, and strontium targets and aluminum fillers that were being installed.

Investigators determined that misorientation of the HSA targets and fillers could have caused a variation of the neutron flux peaking within the flux trap, resulting in operating the advanced test reactor outside its safety authorization basis. In addition, misorientation could also have resulted in a loss of the identity of experiment positions in the east flux trap core position and in the future discharge of the wrong targets or aluminum filler pieces. Early or delayed discharge of the HSA targets or fillers could have impacted the customer’s needs because the capsules would not have received the correct amount of irradiation. Preliminary investigation of this event indicates that a drawing error provided conflicting information and there was insufficient quality organization involvement in the original installation effort.

NFS reported a similar event at the Idaho National Environmental Engineering Advanced Test Reactor Facility in Weekly Summary 98-19. In that event, operators inserted an experiment capsule into the wrong capsule irradiation position. Because the capsule was in the wrong position, it was not discharged from the reactor as scheduled and was overirradiated. The facility manager directed operators to complete a full inventory of all other experiment irradiation positions. They determined there were no other reactor experiment loading anomalies.

At the direction of the facility manager, facility personnel completed the following corrective actions. (ORPS Report ID--LITC-ATR-1998-0008)

- They briefed all advanced test reactor operating crews on the event and the associated lessons learned. Lessons learned included ensuring that operators (1) independently verify reactor loadings, (2) understand the need to be technically inquisitive and raise any concerns to upper levels of management, (3) understand the importance of attention to detail, reactor safety implications, and management/customer expectations for properly loading the reactor, and (4) are informed of the procedure changes made as a result of this event.

- Operators verified that canal transfers were properly inspected and positively identified before the reactor was restarted.

- Facility personnel revised the operating procedure to require operators to physically inventory all capsule experiments after their insertion into the reactor and all capsule locations before final close-up of the reactor vessel and to ensure that capsule experiments are clearly marked before insertion into the reactor.

- Training personnel provided canal operators refresher training on recognizing reactor and experiment components.

However, while performing these corrective actions no one noticed that the east flux trap experiment capsule holder assembly was misoriented.

These events underscore the importance of operators maintaining questioning attitudes and paying attention to detail to ensure configuration control is maintained. Configuration control is important for the safe operation, testing, and maintenance of facility equipment and systems. In addition, if sufficient attention had been paid to involvement of the quality organization in performance of independent verifications, this event could have been prevented. Facility personnel should be trained in the importance of questioning attitudes and attention to detail. They also must be trained in how to correctly perform independent verifications.

These events also demonstrate the importance of multiple engineered barriers to prevent hazardous events. Human performance, supported by procedures, policies, memoranda, or standing orders, can also be an effective barrier. In this event, not only did multiple human barriers fail, but procedural barriers also failed. When multiple barriers fail, managers should investigate to determine if broad programmatic deficiencies exist.

Facility managers should review the following documents to ensure that (1) operations personnel understand their responsibilities and (2) management policies and procedures exist that address proper configuration controls and operator verifications.

- DOE O 5480.19, *Conduct of Operations Requirements for DOE Facilities*, chapter II, “Shift Routines and Operating Practices,” states that the on-duty shift supervisor maintains authority and responsibility for all facility operations. The Order also states that it is the responsibility of the on-shift operating crew to operate the facility safely through adherence to operating procedures and to technical specifications, operational safety requirements, and sound operating practices. Chapter VIII, “Control of Equipment and System Status,” discusses the control and status of equipment and states that the operations supervisor is responsible for maintaining proper configuration. Chapter X, “Independent Verification,” states that independent verification programs should provide a high degree of reliability in ensuring the correct positioning of components. It defines an independent verification as the act of checking a component position independent of activities related to establishing the position of the component.

- DOE/EH-0502, Safety Notice 95-02, “Independent Verification and Self-Checking,” describes a technique that requires workers to (1) stop before performing the task to eliminate distractions and identify the correct component, (2) think about the task, the expected response, and actions required if that response does not occur, (3) act by reconfirming the correct component and performing the function, and (4) review the task by comparing the actual response to the expected response.

KEYWORDS: operations, reactor, experiment, independent verification

FUNCTIONAL AREAS: Operations, Surveillance, Configuration Control, Licensing/Compliance, Procedures

5. WATER INTRUSION AT IDAHO

On February 23, 1999, at the Idaho National Engineering Environmental Laboratory Test Area North Facility, a radiological control technician’s shoes became contaminated with Cs-137 when he walked through water that had become contaminated when it leaked into the facility through ductwork. The technician was conducting a routine weekly radiation survey of a fan room and noticed that radiation readings were higher than those documented in a previous survey. Because of the higher readings, he exited the fan room, performed a personal survey, and detected approximately 2,000 dpm gamma contamination on the soles of both shoes. He then called operations support personnel for assistance and they roped off the area. Radiological control technicians performed follow-up surveys of the fan room and measured up to 23,900 dpm of gamma contamination on the floor. The technician became contaminated and contamination was spread as a direct result of water intrusion. Water intrusion could also damage safety-related equipment, cause false alarm or safety-related equipment actuations, and result in costly equipment repairs or facility clean-up efforts. (ORPS Report ID--LITC-TAN-1999-0002)

Investigators determined that the water came from melting snow that leaked through an open penetration in the side of the building, along ductwork inside the building, and into the ductwork at a split seam. They determined that the water had accumulated on the floor of the fan room but did not determine the exact point that the water leaked out of the ductwork. They also determined that the water became contaminated from legacy contamination in the ductwork. The technician had noticed water on the floor in the fan room but did not think that it was unusual and had stepped in it. Facility personnel were unable to decontaminate his shoes. The facility manager directed facility personnel to issue a work package to decontaminate the fan room, seal the penetration, and locate and repair the leaking ductwork locations. NFS has reported water-intrusion events in several Weekly Summaries. Some examples follow.

- Weekly Summary 97-32 reported two water intrusion events. One of the events involved the improper capping of an unused pipe at the Los Alamos National Laboratory Plutonium Processing Facility. Investigators determined that this allowed water to leak into a 13.2-kV transfer switch, causing a loss of power to the facility and $40,000 in damage. (ORPS Report ALO-LA-LANL-HRL-1997-0001)

- Weekly Summary 97-25 reported that a technician at the Idaho National Engineering Laboratory New Waste Calcination Facility discovered that rainwater had leaked into a safety-significant fire alarm panel, resulting in the failure of interior circuit boards. Investigators reported that the facility's roof had been leaking for some time, and repairs were scheduled for later that fiscal year. (ID--LITC-LANDLORD-1997-0008)

- Weekly Summary 96-39 reported that a commercial nuclear reactor automatically shut down and its safety equipment actuated when water entered a junction box for a main steam isolation valve. The water entered the building through a defective rain gutter. (Nuclear Regulatory Commission Licensee Event Report 91-017-01)

NFS also reported events in several Weekly Summaries in which water from rain, snow, and pipe leaks entered electrical panels, equipment, and buildings. These events resulted in false fire and radiation alarms, fires, criticality concerns, motor failures, spread of contamination, and electrical equipment failures. They illustrate several key lessons. Leaks in building structures or equipment housings that contain safety-related equipment or contaminated material should be repaired quickly to prevent equipment degradation, spurious equipment operation, or spread of contamination. Routine inspections and preventive maintenance programs are important in identifying areas in which facility repairs should be made. Budgetary considerations may not always justify delaying maintenance, especially if personnel can become contaminated or safety-related equipment can become inoperable. Also, facility managers should verify that equipment is protected from the elements.

- DOE-STD-1064-94*, Guideline to Good Practices for Seasonal Facility Preservation at DOE Nuclear Facilities*, provides information for the development and implementation of seasonal weather plans. This standard contains guidance for hurricanes, tornadoes, extreme cold weather, flash floods, and other natural disasters. However, sections of the standard can be applied during periods of heavy rainfall.

- DOE-STD-1010-92, *Guide to Good Practices for Incorporating Operating Experiences*, states: "The use of experience gained should provide a positive method that a facility can use to improve their operations, making them efficient, cost-effective, and safe to the employees, the public, and the environment." Managers, supervisors, and operators should review operating experience information and implement it as the standard suggests. Lessons learned are valuable only if the information they communicate is used.

KEYWORDS: rain, water, corrective actions, maintenance, contamination

FUNCTIONAL AREAS: Corrective Actions, Lessons Learned, Operating Experience, Radiological Protection

6. TWO TRENCHING VIOLATIONS

NFS reviewed two recent occurrences involving violations of OSHA excavation safety requirements by the same construction subcontractor on the same trenching project. On January 19, 1999, at the Savannah River New Tritium Support Facility, two workers entered a trench that appeared to violate OSHA requirements for worker safety. The trench was approximately 6 feet deep and was not sloped to suit the soil condition. On February 17, 1999, an employee was taking measurements in a trench more than 5 feet deep that was neither shored nor properly sloped to prevent cave-in. Each occurrence exposed employees to potential risk. (ORPS Reports SR--WSRC-CMD-1999-0001 and SR--WSRC-CMD-1999-0002)

In the January occurrence, the subcontractor was excavating a trench for the installation of fire protection piping for a new facility. Workers had excavated more than 300 feet of trench that met or exceeded OSHA safety standards. At one point, they had to increase the depth of the trench to approximately 6 feet, for a distance of approximately 20 feet, to clear a buried drain line. This increase in depth below 5 feet required shoring or proper sloping for worker protection. However, the final slope was not consistent with the class C (least stable) soil classification. The facility manager stopped work on the trench pending review and investigation of the occurrence. Workers barricaded the trench to prevent entry to the section not in compliance, completed piping connections outside the barricaded area, and returned excavation depth to the 5-foot level. Corrective actions included the following increases in safety and management field presence.

- The site construction management division assigned a full-time subcontractor representative to oversee the project.
- The subcontractor assigned a full-time safety representative to the project.
- The site construction safety office provided 100 percent safety surveillance for two weeks.

Following the second violation, in February, the facility manager directed the subcontractor to stop all construction activities until further notice. Investigators determined that the competent person[2] had estimated trench depth in both cases instead of measuring it. The facility has issued three notices of safety violation to the subcontractor, one each for the two trenching violations and one for a third occurrence involving the disturbance of an underground utility. Three such notices require the subcontractor to submit a corrective action plan and to stand down all operations for at least half a shift at their own cost for retraining. In addition, the subcontractor has removed the person who was acting as the competent person from supervisory duties.

These occurrences underscore the importance of establishing and enforcing an effective excavation safety program. Although the violations at Savannah River seem minor, worker safety depends on strict compliance with established standards. Excavation cave-ins cause serious and often fatal injuries to workers each year and excavation is recognized as one of the most hazardous of construction operations. Bureau of Labor statistics suggest that cave-ins cause approximately 1,000 injuries in the United States each year. Of 1,107 construction industry deaths reported in 1997, 50 were related to excavation work. OSHA Standard 29 CFR 1926, subpart P, “Excavations,” was developed by analyzing excavation accidents and identifying effective preventive measures. It provides the worker protection requirements for sloping, benching, shoring, and shielding excavations more than 5 feet deep. DOE has incorporated this subpart into its construction safety program for all contractors.

[2] OSHA regulations require employers to assign a competent person to each excavation project. “Competent person” means one who is capable of identifying existing and predictable hazards in the surroundings or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authority to take prompt corrective measures to eliminate them.

Facility operators need to exercise sufficient oversight to ensure that subcontractors comply with safety requirements. Subcontractors will take safety requirements more seriously if they realize that frequent or flagrant violations result in loss of revenue or permanent dismissal or make future contracts difficult or impossible to win. Workers need to realize that safety requirements are developed to protect them, not simply to satisfy requirements. In general, DOE prime contractors have satisfactorily incorporated OSHA requirements into site and facility construction and procurement programs. However, safety violations continue to occur throughout the complex, principally among subcontractors, for reasons that are difficult to determine. Subcontracted construction workers come from a variety of backgrounds, not all of which promote the level of safety consciousness required of DOE contractor and subcontractor employees. The subcontractor involved in the infractions at Savannah River is experienced generally but has limited experience with the DOE safety culture.

OSHA recently revised subpart P of 29 CFR 1926 to make the standards easier to understand, to permit the use of performance criteria where possible, and to provide construction employers with options when classifying soil and selecting employee protection methods. OEAF engineers recommend TED 1-O.15A, *OSHA Technical Manual*, as a valuable compliance and training supplement to OSHA standards. Section V, chapter 2, “Excavations: Hazard Recognition in Trenching,” provides a summary of the OSHA regulations governing excavation safety. It is intended to assist safety professionals in recognizing and preventing trenching and shoring hazards. The entire OSHA technical manual is available at http://www.osha-slc.gov/dts/osta/otm/otm_toc.html.

KEYWORDS: construction, excavation, safety, violation

FUNCTIONAL AREAS: Construction

7. EMPLOYEE SPRAYED WITH ACID

On February 11, 1999, at the Weldon Spring Site Remedial Action Project Water Treatment Plant, a subcontractor employee was sprayed with acid when he inserted into a drum of sulfuric acid (H_2SO_4) a pump that he had been using to pump hydrochloric acid (HCl). When the two acids mixed, a violent chemical reaction caused acid to be sprayed from the drum approximately 10 feet to the ceiling and onto the employee, who immediately flushed the sprayed area at an eyewash station. After later flushing by the site nurse, the employee received treatment and evaluation at a local hospital. He was released on light duty for three days and advised to avoid perspiring and not to wear a respirator. This event is significant because improper handling of hazardous chemicals can cause serious personnel injury. (ORPS Report ORO--MK-WSSRAP-1999-0004)

The subcontractor employee and another employee were pumping 55-gallon drums of concentrated HCl into a holding tank. After several drums of HCl had been pumped into the tank, the pump was inserted into the drum of concentrated H_2SO_4. Investigators determined that when the employees staged the drums for pumping they mistakenly included two drums of H_2SO_4 by failing to carefully read the labels on the drums. The drums of HCl and H_2SO_4 are identical in size and color. The manufacturer and site authorization labels on the drums are similar, except for the names of the chemicals. Investigators determined that the sprayed employee was wearing a full-face respirator and that that he was also wearing a Tyvek™ hood, even though it was not required personal protective equipment for the acid transfer evolution. The interface between the respirator and the hood was not sealed, and the acid reached the employee's bare skin through this gap. Investigators also determined the following.

- Two pumps are used to transfer acid. One pump is used to transfer HCl and the other pump is used to transfer H_2SO_4. The pumps are not marked or labeled to identify which pump is to be used for which acid.

- The HCl and H_2SO_4 acid drums are stored in the same room. There is no physical separation of the drums or any barrier to prevent drum contents from commingling in the event of leakage. Any leakage onto the floor is directed to a common sump for the room.

Corrective actions being taken by Weldon Spring Site Remedial Action Project managers in response to this event include the following.

- Conduct retraining on the compatibility of chemicals using Material Safety Data Sheets.

- Require the use of Tyvek™ hoods during acid handling and sealing of the respirator/hood interface.

- Consider tagging the acid pumps to identify which acid they are used for and evaluate more visible markings on the acid drums.

- Evaluate physical storage separation of the HCl and H_2SO_4 acid drums.

On February 24, while implementing the corrective action to evaluate the chemical storage room for physical separation of the acid drums, employees noticed that the two H_2SO_4 acid drums that had been mistakenly staged were banded together with danger tape to clearly identify them as containing H_2SO_4. The bung of the same drum that had previously sprayed acid was loosely threaded into that drum's bunghole because of a concern that the mixed acids in the drum might have the potential for a chemical reaction that could pressurize the drum. One of the employees thought the flexible polyethylene top of the drum appeared to be bulging and pressed down on it. The bung popped out of the drum, allowing drum vapors to be displaced, and the employees detected the odor of H_2SO_4. One of the employees also detected an acidic taste and sought medical attention from the site nurse and a doctor. He was released for full duty with no restrictions. (ORPS Report ORO--MK-WSSRAP-1999-0008)

NFS has reported other events in which workers came into contact with hazardous chemicals that caused injury. Some examples follow.

- Weekly Summary 98-18 reported that an employee at the Lawrence Livermore National Laboratory received chemical burns to his face when a plastic bottle pressurized, ruptured, and sprayed its contents. Investigators determined the bottle contained sulfuric acid, nitric acid, and acidified hydrocarbon oil. In this event, laboratory workers mixed incompatible materials, which resulted in a lost-time injury. (ORPS Report SAN- -LLNL-LLNL-1998-0025)

- Weekly Summary 98-17 reported that an operator at the Idaho National Engineering and Environmental Laboratory Chemical Processing Plant was sprayed with a nitric acid mist when a hose being used to empty an acid transfer header lifted out of a floor drain. The operator experienced mild irritation in one eye, but medical personnel determined his eye was not damaged. (ORPS Report ID- -LITC-WASTEMNGT-1998-0006)

- Weekly Summary 97-49 reported that an operator at the Idaho National Engineering and Environmental Laboratory Advanced Test Reactor was sprayed with approximately 50 ml of sulfuric acid foam while disconnecting an air hose to the air sparge line of an empty 8,000-gal, bulk-acid storage tank. The acid caused blistering and skin discoloration on the operator's left ear and neck and on the inside of both arms. (ORPS Report ID--LITC-ATR-1997-0025)

These events highlight the need for chemical workers to properly identify and understand the risks involved when working with hazardous chemicals. In facilities where hazardous chemicals are used, workers should be trained in the proper methods for handling, mixing, and storing these chemicals. Facility managers should emphasize the importance of researching all available sources of chemical safety information, particularly when performing first-time or infrequent operations. Information about chemicals, chemical hazards, and chemical safety programs can be located on the DOE Office of Environment, Safety and Health, Office of Worker Safety, Chemical Safety Program home page. The home page is located at http://tis-hq.eh.doe.gov/web/chem_safety/. It provides links to many sources of information, including requirements and guidelines, lessons learned, chemical safety networking, and chemical safety tools.

The following DOE and industry documents provide valuable guidance for all personnel who work with chemicals and hazardous materials.

- DOE-HDBK-1100-96, *Chemical Process Hazards Analysis,* and DOE-HDBK-1101-96, *Process Safety Management for Highly Hazardous Chemicals,* provide guidance for DOE contractors managing facilities and processes covered by the OSHA *Rule for Process Safety Management of Highly Hazardous Chemicals* (29 CFR 1910.119). Both handbooks are available on the DOE Technical Standards home page at http://www.doe.gov/html/techstds/standard/standard.html.

- DOE Defense Programs Safety Information Letter, SIL 96-01, *Incidents from Chemical Reactions Due to Lack of or Failure to Follow Proper Handling Procedures,* provides guidance on preventing accidental chemical reactions as a result of improper chemical storage, handling, shipping, and mixing. Safety Information Letter 96-01 is available at http://www.dp.doe.gov/Public/default.htm.

- 29 CFR 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories*, provides direction on the use of chemicals. It covers signs and labels, spills and accidents, basic rules and procedures, and training and information. 29 CFR 1910.1450 is available on the OSHA home page at http://www.osha-slc.gov/OshStd_data.

- The Office of Environment, Safety and Health provides information in DOE/EH-0296, Bulletin 93-2, *Mixing of Incompatible Chemicals,* about the hazards associated with mixing incompatible chemicals.

- DOE/EH-0557, Safety Notice 97-01, *Mixing and Storing Incompatible Chemicals,* contains lessons learned related to the mixing and storing of incompatible chemicals. It also references a list of chemical incompatibilities provided by the University of Michigan. A copy of the list is available at http://www.orcbs.msu.edu/chemical/chp/appendixc.html. Safety Notice 97-01 can be obtained by contacting the ES&H Information Center, (800) 473-4375, or by writing to U.S. Department of Energy, ES&H Information Center, EH-72, 19901 Germantown Rd., Germantown, MD 20874. Safety notices are also available on the OEAF home page at http://tis.eh.doe.gov:80/web/oeaf/lessons_learned/ons/ons.html.

KEYWORDS: acid, chemical reaction, hazardous material, inattention to detail, injury, occupational safety

FUNCTIONAL AREAS: Industrial Safety, Materials Handling/Storage

8. WORKER INJURED WHILE TROUBLESHOOTING PRESSURIZED SYSTEM

On February 9, 1999, at the Sandia National Laboratory Saturn Accelerator Facility, a worker was troubleshooting a problem with a low-impedance trigger assembly (or spider) when a bolt was expelled from the spider, hitting him in the forehead. The worker was removing bolts from a cover plate on the spider while the spider was still pressurized with an insulating gas. The ejected bolt bruised and cut his forehead. Before he began to work on the spider, the worker had locked and tagged out all electrical energy and gas pressure sources. However, he failed to relieve the residual gas pressure inside the spider. The maximum allowable working pressure of the spider is 90 psi. Investigators estimated the residual gas pressure was less than 20 psi. A co-worker applied first aid (cold compress) and took the injured worker to medical, where his cut was cleaned and sutured. The department manager suspended the troubleshooting activities until his initial analysis was completed. Failure to verify the presence of stored energy resulted in injury to the worker. (ORPS Report ALO-KO-SNL-9000-1999-0001)

The spider, which provides a trigger pulse for the main switches in the Saturn accelerator, looks like a large spider with 36 legs projecting from a 28-in. diameter spheroid. The gas used in the spider as a dielectric is a mixture of nitrogen and sulfur hexafluoride. The cover plate on the spider is held in place by 36 bolts, and the ejected bolt was the 12th one being removed. The worker had been troubleshooting the spider for a number of days and had to test the trigger assembly after each fix to determine if the problem was resolved. He had successfully performed the lockout procedure for each of the earlier trigger tests. On the day of the accident, he had twice performed the lockout procedure without incident. Investigators believe that his mind was occupied with thoughts of his next and final fix, and he forgot to relieve the residual pressure in the spider. Had he remembered to verify a zero-energy condition, the accident could have been avoided.

Facility safety professionals reviewed the circumstances of the incident and concluded that lockout procedures are not always applied to pressure systems as rigorously as they are applied to electrical ones, and that the verification step of the standard lockout procedure is often left out. They are concerned that the worker’s failure to perform the final safety check for stored energy during the lockout process might be a common problem. They recommended that managers ensure that all lockout procedures and their implementation are periodically inspected.

NFS has reported in several Weekly Summaries events where work was performed on pressurized systems without lockout/tagout or without verification that stored energy had been relieved. Some examples follow.

- Weekly Summary 98-27 reported that workers deactivating a glovebox at Rocky Flats Environmental Technology Site found some pressurized air lines when they loosened fittings. The workers believed the lines were not pressurized because they had removed similar, but unpressurized, lines the previous day. In any case, the workers continued to open fittings even after they discovered the pressurized lines. Investigators determined that the workers were not authorized to work on energized systems and that lockouts/tagouts had not been installed. (ORPS Report RFO--KHLL-771OPS-1998-0028)

- Weekly Summary 96-42 reported that a maintenance mechanic at the Waste Isolation Pilot Plant discovered that a compressed air system he was about to work on was pressurized to the full operating pressure of 120 lb. The mechanic believed that the system had been depressurized when it was locked and tagged out of service. Investigators determined that the operators who locked and tagged the air system failed to depressurize it, as required by the lockout/tagout procedure. (ORPS Report ALO--WWID-WIPP-1996-0004)

- Weekly Summary 94-44 reported that a worker at the Lawrence Livermore National Laboratory was contaminated on the face and chest when he disconnected a line pressurized with contaminated air. The worker believed that the line had been depressurized (ORPS Report SAN--LLNL-LLNL-1994-0069)

- Weekly Summary 94-42 reported that a pipe fitter at the Idaho National Engineering Laboratory was sprayed with condensate while attempting to drain a live steam line that he thought was isolated. The steam line was pressurized to 30 psig. Investigators determined that the lockout/tagout had only single-valve isolation and that a tag was hung on the wrong valve. (ORPS Report ID--LITC-LANDLORD-1994-0001)

These events illustrate the potential hazards to personnel who knowingly or unknowingly work on pressurized systems or isolated systems that contain stored energy. In August 1995, three mechanics at a commercial power plant were burned by flashing steam when they attempted to repair a valve in a pressurized water system. In September 1993, three workers at a commercial nuclear power plant received first- and second-degree burns from high-pressure steam when they worked on a valve in a system that they believed was depressurized and isolated. It is important that workers verify that proper isolation boundaries have been established and that stored energy has been relieved before starting the work. Following are some of the many documents that facility managers should review to ensure that safe work practices associated with potentially pressurized systems are incorporated in their facility safety programs.

- DOE-STD-1030-96, *Guide to Good Practices for Lockouts and Tagouts*, section 4.2.3.3, states that systems, portions of systems, and components that operate at temperatures and pressures above ambient should be vented and, if necessary, drained or cooled. Section 4.5.1 states that potentially hazardous stored or residual energy must be relieved, disconnected, restrained, or otherwise rendered safe. If it is possible for stored energy to reaccumulate, a means should be provided for workers to verify that a safe level exists until they complete the work. This guidance is also repeated in DOE 5480.19, *Conduct of Operations Requirements for DOE Facilities*, chapter IX, "Lockouts and Tagouts," section 6.e, "Stored Energy."

- DOE/EH-0540, Safety Notice 96-05, *Lockout/Tagout Programs,* recommends that workers be cognizant of lockout/tagout boundaries and verify that no hazardous energy exists within these boundaries.

- The *Hazard and Barrier Analysis Guide*, developed by OEAF, discusses barriers that control the hazards associated with a job. The guide also provides a detailed analysis for selecting optimum barriers, including a matrix that displays the effectiveness of different barriers in protecting against some common hazards.

DOE technical standards are available at http://www.doe.gov/html/techstds/techstds.html. OSHA regulations are available at http://www.osha-slc.gov/OshStd_data. Safety Notice 96-05 can be obtained by contacting the ES&H Information Center, (800) 473-4375, or by writing to U.S. Department of Energy, ES&H Information Center, EH-72, 19901 Germantown Rd., Germantown, MD 20874. Safety notices are also available at http://tis.eh.doe.gov:80/web/oeaf/lessons_learned/ons/ons.html. A copy of the *Hazard and Barrier Analysis Guide* is also available from the ES&H Information Center or at http://tis.eh.doe.gov:80/web/oeaf/tools/hazbar.pdf.

KEYWORDS: bolt, injury, lockout and tagout, maintenance, pressurized

FUNCTIONAL AREAS: Hazards and Barrier Analysis, Mechanical Maintenance, Operations

FINAL REPORT

This section of the OEWS discusses events filed as final reports in the ORPS. These events contain new or additional lessons learned that may be of interest to personnel within the DOE complex.

1. FIXED CONTAMINATION BECOMES REMOVABLE

On November 23, 1998, at the Hanford site burial grounds, health physics personnel detected removable contamination exceeding DOT limits on a truck shipment of equipment removed from the General Atomics hot cell decontamination and decommissioning project in San Diego, California. The source of the contamination was a fixative coating on one of the pieces of equipment that peeled off the equipment because the coating was not adequately bonded. This occurrence illustrates one way in which fixed contamination may be rendered removable. (ORPS Report SAN—GOSF-HCF-1998-0001)

On November 20, 1998, workers at the General Atomics facility loaded the flatbed trailer with five sealed cylindrical steel well structures removed from the floor of the hot cell facility. Health physics personnel surveyed the load and determined that it met DOT smearable and dose requirements for shipment. They covered the load with two plastic tarps, surveyed it again, and transported the equipment to Hanford. When it arrived there, health physics personnel in the Hanford 1100 receiving area surveyed the shipment. They found no dose rate inconsistencies with the shipping documents nor inappropriate levels of surface contamination. When the shipment arrived at the burial grounds, the tarps were removed and the load was surveyed by a radiation control technician, who discovered removable contamination on one of the wells. Technicians conducting follow-up surveys found contaminated paint chips and removable contamination as high as 35,000 dpm/100 cm^2 beta/gamma. One spot on the ground under one tarp had a radiation level of 35 mrad/hour. They did not detect alpha contamination. No personnel were contaminated during the unloading or clean-up process.

Investigators determined that the fixed contamination became removable because of less-than-adequate bonding of the fixative coating to the metal surface of one of the wells, which was in turn because of inadequate surface preparation. They also believe that bond failure of the fixative coating may have been aggravated by the tarps rubbing against the wells during shipment. The facility manager identified the root cause of this occurrence as a defective or inadequate procedure for applying the fixative coating.

The fixative coating used on the wells was the Polymeric Barrier System™. This coating is a single-component system that can be easily applied in the field to form an impermeable, flexible barrier between hazardous and radioactive materials and the environment.

The facility manager identified corrective actions to prevent a recurrence. These corrective actions included revising the packaging procedure to assure a clean, dry surface before the fixative coating is applied and requiring an outer plastic or other appropriate wrap for contaminated objects in addition to the fixative coating.

DOT requirements for shipping radioactive materials may be found in 49CFR 173.403, *General Requirements for Shipments and Packagings*, subpart I, “Class7--Radioactive Materials.”

An abstract describing the Polymeric Barrier System™ is available at http://www.research.uc.edu/~ipo/NewTechs/Item87.html.

KEYWORDS: barrier, coatings, decontamination and decommissioning, fixed contamination, removable contamination, transportation

FUNCTIONAL AREAS: Decontamination and Decommissioning, Environmental Protection, Radiation Protection, Transportation

OEAF FOLLOW-UP ACTIVITY

1. OCCURRENCE REPORTING PROGRAM SURVEY

EH-33 has developed a survey to help determine how well its products and services meet the needs of its customers throughout the DOE complex. Besides the DOE and contractor organizations in the field that generate occurrence reports, customers include other organizations that rely on occurrence reports and the Occurrence Reporting and Processing System (ORPS) database for notification, analysis, and lessons learned. The objective of this survey is to get a big-picture look at the major elements of the DOE Occurrence Reporting Program from the customer's point of view. The survey includes the following elements.

- Occurrence Reporting Order/Manual
- ORPS database
- Occurrence Reporting Program home page
- ORPS Bulletin
- Occurrence Reporting Special Interest Group

Please note that this survey is intended for DOE and DOE contractors only, since ORPS access is limited to those groups. To help EH-33 determine what is and is not working well, please answer the survey by March 15, 1999.

The survey is provided as a pdf file that can be found as a new link on the Occurrence Reporting Program home page at http://tis.eh.doe.gov/oeaf/orps.html. You must have Adobe Acrobat Reader installed to open the file. If you are unable to open and print the survey, please contact Eugenia Boyle at phone number (301) 903-3393 or eugenia.boyle@eh.doe.gov**.** Instructions for completing and submitting the survey are included on the survey form. The responses will be compiled and the results published in the April ORPS Bulletin (also available from the Occurrence Reporting Program home page).